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Water Resources Research: Issues For the 1980's and Beyond

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Water was recently selected by a Delphi panel of natural resources development experts as being the most important natural resources issue facing 13 of the Rocky Mountain and Great Plains states (7). The Delphi panel indicated that in their collective judgment water resources would become a very serious problem for the study region by the early 1990's. The group also noted that water issues had already become problematic in the study region and were becoming progressively more serious over time.

Water has also been identified by members of the North Central Regional Committee on Natural Resources Use and Environmental Policy (NCR-111) as one of the most important natural resources issues for the North Central Region (NCR). While specific natural resources issues have not been prioritized by the NCR-111 committee, water problems have been perceived to be very important research issues in the NCR. Evidence of the perceived importance of water problems in the NCR is the recent water resources research symposium sponsored by NCR-111, the Farm Foundation, the Ford Foundation, the Natural Resources Economics Division of the Economic Research Service, and the Soil Conservation Service.

The purpose of this paper is to present a synthesis of the efforts of the NCR-111 committee which has been examining natural resources development issues since 1978. Particular emphasis will

be focused on the papers presented at the water resources symposium because they tend to closely reflect the perceptions of the NCR-111 group. While the primary focus of the paper is on water resources issues in the NCR, it is argued that many of the research topics identified at the symposium and in other NCR-111 deliberations are quite appropriate for other geographic regions of the country.

The symposium participants represented several disciplines with different perspectives to contribute to water resources research. During the course of the symposium, the participants identified numerous research topics that could potentially contribute to the resolution of several water resource problems which exist in the NCR. The paper is organized around the major problems discussed at the water resources symposium and at previous NCR-111 meetings. The potential contributions of the various disciplines are briefly discussed under each subheading. The research problems examined in this paper are: competition for water, water augmentation, irrigation, water quality, drainage, and the social impacts of diffusion of technologies and water policy. The discussion of these topics compose the body of the paper.

An assumption which has guided the operation of the NCR-111 committee since it came into being is that natural resources problems cannot be addressed without adequate technical, social and economic information bases (1-6,8-9,11-12). Water resources policies conceived and implemented without adequate knowledge of the scope of water

problems, the factors contributing to the problems and the actions necessary to solve them will probably be ineffective. Unfortunately, the state-of-the-art in water resources research has not advanced to the point where adequate knowledge bases exist which may be used to develop macro-level water resources programs. While much water resources research has been effectively conducted (1-6,8-13), there are many issues which must be examined before integrated water resources planning and development programs can be implemented. The committee has endeavored to identify natural resources research topics which have the potential of contributing to problem resolution in the NCR. Therefore, the last section of the paper is devoted to a discussion of future water research priorities in the context of regional and subregional research needs as well as existing research commitments within the NCR.

Competition For Water

One of the most important research issues associated with water resources, at least in the short-run, is who will have access to existing and future water supplies (1-3,6,8,12,13). Competition for existing water is already present in many areas of the NCR and will probably become more serious as the demand for high quality water expands without concomitant increases in water supplies. This is especially true in the western portion of the region where ground water from the Ogallala Aquifer is being depleted due to excessive pumping for irrigation purposes (1-5,11,12). The consequences of this competition for limited water supplies throughout the region

has been inefficiencies in terms of use of the resource and inter-group conflict concerning access. It is highly probable that the conflicts will become intensified as water becomes more scarce.

The preceding materials strongly suggest that some claimants will be denied access to water. Those denied access may elect to pursue a conflict approach to problem resolution. Such conflict is often dysfunctional to communities and/or societies and must be resolved quickly. The solution of conflict situations among potential users combined with an increase in the efficient use of existing water supplies will probably require the formation of institutional mechanisms to regulate the use of existing and future water supplies. Such institutional entities, however, will probably require enforcement authority to ensure compliance. Research could be quite useful in the identification of effective and efficient methods of distributing scarce resources. Alternatives such as the market system could be contrasted with other options such as mandated exclusion to evaluate their effectiveness and efficiency in distributing scarce resources (6,13). Use of federal and state agencies presently engaged in water programs could be contrasted with alternatives such as local decision-making bodies. Such research could provide insight into the best method(s) for resolving problems associated with competition for the scarce resource.

A closely aligned research question is what criteria should be applied in the decision-making process. The outcome of the decision-making must be equitable as well as resulting in more

efficient use of the scarce resource. To accomplish this goal will require the involvement of a broad cross-section of the society so that all interests are represented. National surveys to establish goals and criteria for decision-making will probably be required (6).

Allocation decisions are complicated by the fact that some uses are not compatible with others (2,3). Agricultural use of water via irrigation or natural rainfall, for example, frequently contributes to lower water quality due to sedimentation and chemical pollution associated with soil erosion (2-4,8,11-13). These agricultural pollutants adversely affect other uses such as recreational, residential, industrial, navigational, and wildlife habitat (2,3,8). Industrial and urban effluents may well render water bodies unfit for recreational use and greatly increase the economic costs of making polluted water potable. Wildlife is oftentimes considered a residual claimant on existing water supplies and suffers greatly because habitat is often disrupted and/or destroyed by consumptive water uses (3,8). Research may provide insight into how multiple uses can be made more complimentary thus making it possible to extend the number of uses and users of existing water supplies.

It is quite possible that established water rights will be challenged in the future and that new rights will be formulated in the context of contemporary social, economic and technological realities (12). The interests of all claimants must be considered in the development of new water rights, especially the rights of

future generations who are not present to advance their own cases. The above-mentioned research efforts would provide a starting point for the establishment of the mechanisms to address these problems. If the mechanisms for reducing competition among water users are not developed, it is highly probable that political, social and economic struggles will become more serious which may result in more inefficient and more inequitable uses of existing water supplies.

Water Augmentation Research

A research area closely linked with competition for limited water resources is augmentation of existing water supplies. Assuming a continual expansion of demand for high quality water, efforts should be initiated to supplement existing water sources (9). If new water supplies cannot be generated, competition for the existing supplies will continue to become more intense and fewer development goals will be accomplished. Research initiated in the NCR to examine the technical, social, economic and political feasibility of expanding water supplies may return great benefits to the region and the society in terms of expanding socio-economic development opportunities that are closely related to available water supplies (industrial development or expansion of housing may be restricted by lack of access to water). The high demand for irrigation water in the western portion of the region (NCR) combined with expanding needs of residential-industrial consumers in the northern and eastern portions of the region make water augmentation research

a regional issue. There are several ways in which existing water resources may be augmented such as: interbasin transfer of water (intra- and inter-state as well as inter-society) (3), development of upground reservoirs (9), weather modification (13), development of additional subsurface aquifers, reclamation of polluted aquifers (8,12,13) and use of urban waste water (5).

A possible approach for reducing geographic scarcity of water is through interbasin transfer from water surplus areas to those deficient in the resource (3). While the existing research indicates that the costs of interbasin transfer are prohibitive at the present time, changing technologies and/or necessities for survival of a specific region may justify investment in such projects. Water diversion projects deemed economically not feasible under previous circumstances may become a good investment under conditions of scarcity. Research is needed to assess the social, technical, economic, environmental and political feasibilities of interbasin transfer. Particular attention should be focused on transfers which require transport of water short distances between receiving and contributing basins.

Sociological and political science research are important elements of interbasin transfer research and become even more important should the transfer occur across international borders. Maintenance of close political and social relationships among communities, regions, states and nations is very important. Research to facilitate social and political understanding of interbasin

transfers may be important in determining whether or not such transfers ever occur. People in both the receiving and the contributing basins must feel the exchange relationship is equitable and beneficial to all parties involved.

The construction of reservoirs may be an attractive development strategy in areas plagued by periodic drought and extensive demands on existing water supplies. Even arid regions have periods of excessive rainfall and/or have stream flow which could be captured for use in dry periods. While all disciplines contribute to impoundment research and aid in the decision-making process, greater reliance should be placed on social science research to address the adverse social and economic consequences of impoundments on local people (9). Heretofore, sociological assessments have played a minor role in the decision-making process. While economic analyses have received much more attention than sociological evaluations, many economic factors have been ignored. Technical and environmental analyses tend to receive the greatest weight in the decision-making process but social impact assessment has demonstrated that lake projects frequently generate negative economic and social consequences for local people (9). Additional sociological and economic research is needed to devise means of mitigating adverse consequences for directly impacted people who are forced by eminent domain laws to assume disproportionate costs of regional and societal development (6,9).

Research focused on the environmental, technical and socio-economic feasibilities of augmenting water supplies via weather

modification may prove useful in the future (13). Technologies may be developed which can produce greater rainfall in arid regions thus influencing the socio-economic viability of the region. The social and economic costs to areas deprived of the moisture, however, would have to be considered in such research. Manipulation of the environment at a cost to other claimants raises many issues about water rights.

A serious problem for the NCR is ground water pollution which reduces the amount of available water. Research is needed to devise methods of reclaiming polluted underground water supplies (2,8,11,13). Relatively little is known about how to counteract subsurface water pollution. Fertilizers, pesticides, salts, industrial wastes, and other foreign substances frequently contaminate subsurface water supplies to the point they can no longer be used. Research to isolate cost-effective means of reclaiming polluted aquifers would do much to enhance existing water supplies in the NCR.

Research devoted to the isolation of methods to rapidly recharge aquifers would also be extremely useful. It is basically assumed that cost effective techniques for recharging aquifers are not available but research may create the technologies and techniques to do so.

A promising area of water research is the technical, economic, social, and environmental feasibility of surface application of human wastes in liquid form (5). Urban waste water could be a very valuable source of usable water for agriculture if potential contaminants can be controlled and farmers accept the wastes. Special

attention should be focused on the potential problems of heavy metal contaminants frequently associated with urban wastes. Research should be undertaken to ensure that environmental and physiological damage to humans will not occur from heavy metals when urban wastes are applied to agricultural lands. If techniques can be developed which will transform urban wastes into environmentally safe materials which are economical to apply both farm and city groups will benefit. Farmers would have access to new sources of water and plant nutrients while urban dwellers would have access to sites where wastes can be deposited. It is also possible that the urban waste products could become a source of revenue for cities.

Water conservation efforts could also contribute to the solution of water scarcity problems by making existing water available to more users. Plant scientists can contribute to water conservation efforts by the development of new plant varieties which consume less water and release less water via leaf evaporation (5,11,12). Engineers may be able to further refine irrigation technologies which will reduce evaporation and run-off when water is applied (4,11). Engineers may also play a very important role in the development of cost-effective methods of subsurface applications of water so that surface evaporation can be reduced (4,11). Subsurface application technologies may contribute to more extensive use of urban waste water in agriculture since offensive odors would be less of a problem. Technological innovations which permit efficient injection of waste products into the soil may

increase the acceptability of agricultural use of human wastes by farmers.

Conservation tillage research is needed to develop agricultural techniques which will increase the moisture retention capabilities of soil (1,4,5,8,11). No-till not only conserves soil by reducing soil movement but also is useful in maintaining soil moisture. The water conservation potential of different tillage techniques could be examined so that appropriate recommendations can be made to farmers under different farming conditions.

Conservation of existing water supplies is not the sole responsibility of agriculture. Urban-industrial users should be strongly encouraged to conserve water. Studies focused on the feasibility of water recycling, for example, could produce innovations that could greatly reduce urban-industrial demands for water. Research needs to be initiated among urban residential users as well to ascertain what types of water use efficiencies can be achieved. It is highly likely that water use could be greatly reduced by changes in life-styles.

Irrigation Research

A very important area for research in the western portion of the NCR is irrigation (1-6,8,11-13). Several disciplines have contributed to irrigation research but many problems remain to be solved. Development of more efficient irrigation systems through technological research is highly desirable. Application technologies

which deliver water at variable rates to eliminate soil erosion and reduce evaporation from the surface are needed (4,11). Additional research is necessary to make irrigation systems more energy efficient as the economic costs of energy increase.

Timing of application during the growing cycle offers hope for reducing water requirements (1,4,11). It is possible that research will produce technologies which can monitor water needs of plants so that optimum application of water is achieved (5,11). Research focused on in-field monitoring of plant needs combined with improved irrigation application systems may prove to be important in maximizing crop production with the least amount of water.

A very fruitful area of research for both physical and social scientists in the NCR is the impact of "forced reduction" of irrigation due to ground water depletion (12,13). Eventually the Ogallala Aquifer will become depleted to the point that irrigation pumping will no longer be feasible from many perspectives (economically, socially, politically and environmentally) (1,2,4,5,11-13). One possible outcome will be the shift of agricultural production from the western portion of the NCR to more humid areas of the region (12,13). Researchers should begin to examine the potential adjustment problems for the irrigated areas of the NCR which will lose economic viability in terms of agriculture. Similar research will be required for the more humid areas which will be called upon to increase productivity. Many research questions will emerge when agriculture

must be reduced in the western portion of the NCR. Will the more humid areas of the region be able to expand agricultural production to compensate for losses in the irrigated areas? If so, what will be required to accomplish the expanded production? What are the environmental, social, economic, and political consequences for the "losing" areas and the "gaining" areas? How will the difficult allocation decisions be made in the "losing" areas in terms of the limited water which will be avilable for irrigation? Who will make the decisions that some farms will survive while others will be eliminated? What criteria will be used in the decision-making process relative to accessing limited water supplies? How will displaced farmers in the "losing" areas be re-integrated into the economic institution of the society? Unless these questions are addressed considerable social unrest and conflict will result. If research can provide some solutions to these problems, then some of the adverse consequences may be avoided.

Drainage Research

From time to time all areas of the NCR experience periods of excess water. Flooding and surplus ground water pose problems for all segments of the region occasionally and some locales frequently. Research is needed to develop new technologies which will effectively and efficiently remove excess water from agricultural lands. Drainage systems to remove excess water may also be used for subsurface irrigation and some research attention should be devoted to this topic (13)

Wetland research is sorely needed in the NCR (3,8,10,11,13). Relatively little research has been conducted on the socio-economic and environmental impacts of draining wetlands such as potholes and marshes. When wetlands are drained and put into agricultural production a valuable resource is lost and the agricultural production derived from drained marsh land is often much less than other types of farm land. Wildlife suffers due to loss of habitat, catch basins for agricultural pollutants are lost, certain types of recreation potential is destroyed, the land brought into agricultural production is often eroded at higher rates than prime agricultural land which contributes to water pollution, and other adverse effects are often generated when wetlands are drained. Research is needed to ascertain the best use of wetlands from a social, economic, and environmental perspective. Research may develop techniques for wetland owners to realize economic benefits from the resource in its natural state. Particular emphasis should be placed on the possibility of using wetlands for recreational purposes which can produce income for the landowner.

Recreational use of farm land should be examined on a much broader basis than in the past. If cost-effective mechanisms can be developed to provide farmers with supplemental income via purchase of recreation-use rights, marginal wetlands may be retired from agricultural production to become wildlife habitat with the long-run effect of reducing soil erosion and water pollution. This type of research is appropriate throughout the NCR.

Economic research of the costs and benefits of bringing wetlands into agricultural production is worthwhile (8,13). Assessment of the environmental and recreational losses compared with agricultural gains of draining wetlands are important research topics. What are the social, economic, recreational and environmental benefits and costs of wetland drainage? What are the long-run environmental effects of wetland drainage? What may appear to be a wise decision in the short-run may prove to be adverse using longer time horizons.

Water Quality Research

Availability of water is not the only issue facing water resources researchers in the NCR. Of equal concern is water quality (2-4,8,11-13). Existing water supplies must be in a form that are usable or they are of little consequence.

There are many contributors to water pollution in the NCR. Urban-industrial pollution (point pollution) is one of the most significant sources. Natural resources researchers in the land grant system cannot divorce themselves from point pollution because such pollution does occur in rural areas. Small towns and industries located in rural areas often contribute contaminants to waterways. As decentralization of industry continues in rural areas, point pollution will be compounded. Research needs to be initiated that will generate data which will be helpful in reducing externalities associated with waste elimination among these pollutors. Economic

analyses of alternative waste control systems may identify systems which are appropriate for small industries or towns. Physical scientists could be encouraged to develop cost-effective technologies for reducing point pollution. Special attention could be directed toward development of inexpensive techniques for processing human wastes since many rural communities frequently do not have the economic resources for financing costly sewerage treatment facilities even when federal and/or state monies are available to subsidize these efforts.

Point pollution research is needed in the mineral extractive industries (3). Strip and deep shaft mining can and do contribute to reduction in water quality. Research designed to develop cost-effective techniques for controlling acid drainage in coal mining areas of the NCR would be very beneficial. Reduction of acid drainage will benefit many groups such as recreators and community groups who must make the polluted water potable for human consumption.

It is recommended that research be initiated which will isolate means of reducing ground water pollution. Better application techniques in the use of fertilizers, pesticides and herbicides would be helpful in reducing the problem. Ground water pollution will probably become even more critical as minimum and no-till agricultural practices become more prevalent. Such techniques increase percolation of water through the soil which leaches out chemicals that are ultimately dispersed in ground water supplies. Minimum and no-till systems also require greater chemical inputs to effectively control

pests which increases the probability that ground water will be contaminated using such practices (8,11,13). Cooperative research endeavors by research scientists concerned with soil erosion control practices (minimum and no-till systems) and ground water pollution appears to be desirable. Extensive adoption of minimum tillage practices combined with chemical additives to maximize output may reduce soil erosion but contribute to more rapid and extensive pollution of ground water supplies. Perhaps through cooperative research both goals (reduced soil erosion and reduction of groundwater pollution) may be realized.

Nonpoint water pollution research holds great promise for improving water quality in the NCR. Of critical need is the development of monitoring systems which will make it possible to identify nonpoint water pollutors. Such technologies would change nonpoint pollution to point pollution and individual pollutors could be influenced to internalize their externalities by many techniques which range from social pressure to fines. A potential useful avenue of technological research would be satellite photography to be used for isolating the nature and magnitude of agricultural pollution. It may become technologically feasible to develop a system of photo monitoring combined with computer data storage and evaluation which can effectively measure pollutants from individual farms as well as urban properties.[2] Such technological developments would make it possible to initiate water policies which would "force" land owners to stop polluting. Another mechanism for technological

monitoring is in-stream monitoring of pollutants. Commitment of resources to develop better technologies and methods of monitoring such pollutants could prove very useful in forcing land owners to reduce and/or eliminate pollution.

The need for more extensive research to reduce soil erosion has been addressed quite adequately in the Halcrow-Seitz paper. We will only comment that considerable improvement in water quality can be achieved by reducing soil erosion which contributes sediment, pesticides, herbicides and inorganic fertilizers to water bodies.

Social Impacts and Diffusion of Technologies and Water Policy

The generation of new technologies and techniques to address water problems is an essential element of problem resolution but the potential users of the innovations ultimately control the destinies of the new creations. Individual farmers, business persons, workers, and consumers determine whether or not the expected outcomes of technologies and techniques are realized. One of the most important roles for sociologists and economists is to examine the factors that contribute to or inhibit adoption of technologies and techniques which will contribute to reduction of water use and abuse in the NCR.[3]

Adoption research is paramount to the understanding of the potential impacts of new technologies and techniques associated with resolution of water problems in the NCR. If the research of the physical scientists is to be effective, farmers will have to adopt new farm machinery, employ new plant varieties, accept nontraditional

water application techniques, integrate innovative drainage systems into farming practices, modify existing tillage systems, become skilled in computer hard and soft ware systems and adopt many other innovations. To assume that farmers will do so without hesitation is a false assumption for there are many variables which will impede adoption. Economic factors will undoubtedly prevent many farmers from adopting for they have made investments in existing technologies and techniques which must be continued for an extended period of time to recover their investments. Management practices employed in the past have certain levels of certainty attached to them and technological systems often require some degree of management change. Even slight modification of farming practices introduces some personal risk into their lives. Past experiences with certain cropping practices and management decisions are not easily forgotten and abandoned. Attitudes developed over many years of farming are difficult to change if the behavioral outcomes associated with existing practices are perceived to be good.

The nonfarming sectors of the society will also be resistant to change even when technologies are made available to solve problems. This resistance will be greater if behavioral change is required to solve the problem. Contributors to water pollution will seldom voluntarily internalize their externalities because they do not have to pay the costs of making the water usable once again.

A vital research question is how do we introduce technologies and techniques so that the beneficial effects can be achieved? Research

devoted to isolating impediments to adoption can accelerate adoption rates and reduce the time from problem identification to problem resolution. To assume that making people aware of innovations via educational programs is sufficient to bring about adoption is subject to severe skepticism. Empirical evidence suggests that awareness is a necessary but not sufficient condition for bringing about change.

Joint research needs to be initiated throughout the NCR by sociologists and economists to identify the sociological, psychosocial and economic constraints to adoption of new technologies and techniques. New theoretical paradigms will be required and tested to build knowledge bases to identify and hopefully remove blockages to adoption.

Another important research topic for social scientists is the social and economic consequences of technological innovations and water policies. Joint research by sociologists and economists may identify problems created for various subcultural groups by technological development. Such research may provide insight into how the inequities or problems may be solved. Reduction and/or elimination of the problems associated with water scarcity by creating major problems for specific subgroups in the society is not a desirable outcome for the land grant system. Social scientists trained in evaluative research methodologies could play a very useful role in assessing the social impacts of agricultural programs.

Conclusions

The literature reviewed in this paper strongly suggests that several water resources issues are now problematic in the NCR and will probably become even more acute in the near future. While NCR researchers have responded to the emerging water resources problems, as evidenced by a fivefold increase in the number of water research projects since 1950 (10), there are many water issues which have received relatively little attention. The large increase in the number of water projects in the last 30 years is also misleading because the research commitments made prior to 1950 in the NCR were relatively small. Currently, there are 503 water related projects in the NCR (10) and these projects address several of the water problems identified in this paper.

Examination of the number of water resources projects in the NCR during the last thirty years demonstrates that water projects peaked in the early 1970's and have remained stable or have declined slightly over time. This is a very important observation since evidence to date strongly suggests that water problems will probably become more serious in the future. The decline of research commitments to water problems at a time when water issues are becoming more serious makes it more difficult to address the problems.

Inspection of the topics being addressed by researchers in the NCR provides insight to research problems which are being ignored. A majority of all current projects in the NCR are focused on the physical aspects of the resource. During the last decade 57% of all water projects in the NCR were devoted to the examination of

the physical relationships of water (soil to water, plants to water, etc.). Water quality studies composed 24% of the total projects while 17% were devoted to economics and management (10). Currently, 70.6% of the research projects are devoted to the physical relationships of water, 20.9% to water quality and 8.5% to economics and management. Practically nothing is presently being committed to sociological research and very little to political science. Social impact assessment of water policy and water programs are not represented in the current water projects. The adoption of water conservation practices and technologies are not being researched as well. The socio-economic impacts of various water policies have been basically ignored. Research designed to evaluate alternative institutional mechanisms for allocating scarce water supplies have not been studied. Social and economic incentives for conserving water have not been adequately researched. Research designed to involve a broad spectrum of the public in decision-making about water policies has not been conducted to date. The use of human wastes in slurry form for surface application has received recent research attention in the NCR but is certainly worthy of continued commitment. Wetland research and research focused on recreational use of water resources have not received much research support even though the findings could contribute to the resolution of certain types of water resources problems identified in the region. Even a cursory overview of existing research efforts in the NCR suggests that several water resource problems which exist in the NCR are being ignored.

Another conclusion drawn from the literature reviewed in this paper is that a need exists for cooperation in the conduct of water resources research. Observations to date suggest that resolution of one water resources problem frequently results in the creation of others which are often as negative as the original issue that precipitated action. Research which takes a more wholistic approach to problem resolution in the area of water resources may be a much more fruitful endeavor than independent efforts. This suggests that integrated research programs will probably be required to address water problems. Ground water, for example, may be degraded by tillage practices that are designed to conserve topsoil. Use of chemicals such as pesticides and fertilizers may make minimum tillage economically feasible but result in further degradation of ground and surface water. Integrated research programs devoted to the resolution of general water resources problems (such as improved water quality) have a greater probability of avoiding some of the pitfalls of issue specific research focused on a very narrow topic. Such an orientation implies that priority for funding future projects should be given to those which are more wholistic in scope and involve multiple disciplines.

A final conclusion drawn from the materials examined in this paper is that some of the research projects presently underway or that could be implemented in the NCR have application throughout the region while others are very localistic. The research topics which are regional in scope are:

1. Ground water pollution
2. Water conservation technologies and practices

3. Impacts of water policy and adoption of technologies
4. Recreational use of water
5. Remote sensing
6. Physical relationship of water.

There are several water research topics, however, which are primarily confined to specific geographic subregions. The specialized topics are:

1. Irrigation research which is primarily relevant to the western portion of the region.
2. Drainage of wetlands (potholes) which is particularly appropriate to the northern portion of the NCR.
3. Control of acid drainage from coal mines which is appropriate for the eastern and northern portions of the region.
4. Drainage systems for removing excess surface water which is appropriate in the eastern and northern portions of the region.
5. Interbasin transfers which would be most appropriate, at least in the short-run, to the western portion of the region.
6. Monitoring in-field water use and water application which is most appropriate in the western portion of the region.

Each of these topics is worthy of research but priorities will be required since all of the issues identified in this paper probably cannot be funded simultaneously. Transferability of research findings may be a useful criteria for establishing research priorities because findings which are generalizable will reduce the need for replication throughout the region.

In sum, the literature reviewed in this paper strongly suggests that many water resources problems exist in the NCR but that traditional research approaches may not be the most appropriate means of addressing them. The literature demonstrates that the physical aspects of water are being emphasized with relatively few research resources

focused on the human dimensions. Funding agencies and land grant decision makers may find it helpful to re-examine these allocations in the context of the goals to be achieved and the roles social scientists can play in the resolution of water related problems in the region.

FOOTNOTES

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2. Information received during informal discussions at the Soil and Water Resources Conservation Act of 1977 Symposium, December 5-9, 1982, Washington, D.C.

3. Much of the discussion is based on a very large body of literature on adoption behavior in Rural Sociology.

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